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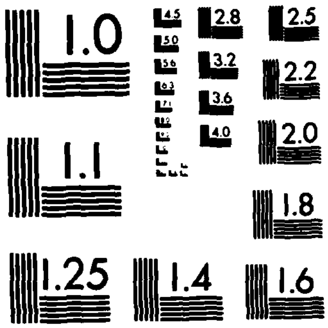

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NAVAL UNDERWATER SYSTEMS CENTER
NEWPORT LABORATORY
NEWPORT, RHODE ISLAND 02840

Technical Memorandum

THEORETICAL CONSIDERATIONS AND USER'S MANUAL FOR A MODIFIED XYZ POTENTIAL FLOW PROGRAM FOR CALCULATING FIVE DEGREES-OF-FREEDOM VELOCITY POTENTIALS

Date: 15 November 1982

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Test cases of a sphere and 2:1 ellipsoid were run and results compared well with known analytic solutions.

The latter sections of this report are intended for use as a user's manual.

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The XYZ Potential Flow Computer Program (XYZPF) has been modified to include the calculation of perturbation and total velocity potentials for on-body and off-body points. The program's capabilities have also been extended from three to five degrees of freedom by incorporating calculations for two rotational degrees of freedom of the body (body rotation about its Y and Z axes). In addition to these modifications which increase the program's capabilities, the program, which was originally written for a CDC 6700 computer, was rewritten to fit on a PDP 11/34 computer.

Test cases of a sphere and 2:1 ellipsoid were run and results compared well with known analytic solutions.

The latter sections of this report are intended for use as a user's manual.

ADMINISTRATIVE INFORMATION

This memorandum documents work performed under IRIED Project No. A43105, "Torpedo Launch Force Due to Bernoulli Effect," Project Engineer -- Paul Lefebvre (Code 3711). The sponsoring activity is the Naval Underwater Systems Center (Code 10), Dr. W. A. Von Winkle.

The original XYZPF was written by Charles W. Dawson and Janet S. Dean (David Taylor Naval Ship Research and Development Center) and is presently maintained by J. S. Dean.

The author of this memorandum is located at the Newport Laboratory, Naval Underwater Systems Center, Newport, Rhode Island 02840.

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ACKNOWLEDGMENT

A significant effort on the part of Robert Thibodeau (Launcher Department Staff, Code 3701) is to be commended. Through his efforts, the original David Taylor Naval Ship Research and Development Center's version of the XYZPF program was installed on a PDP 11/34 minicomputer and was rewritten to be executed interactively.

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1.0 INTRODUCTION

The Naval Underwater Systems Center (NUSC) version of the XYZ Potential Flow Computer Program (XYZPF) described in this report was written under an ongoing NUSC IRIED project titled "Torpedo Launch Force Due to Bernoulli Effect." The main objective of the project is to create a hydrodynamic coefficient computer code to calculate the unsteady forces and moments on a body travelling with five degrees of freedom (D.O.F.) motion (three translational motions, u, v, w, and two rotational, q, r) in close proximity to a wall or other structure.

The hydrodynamic coefficient code is presently being developed and will be described in a future technical memorandum. Input to the code will require the velocity potential distribution on the surface of the body for all five degrees of freedom.

The XYZPF was chosen as the basis for calculating this velocity potential distribution since it utilizes a very general singularity method to conveniently calculate the potential flow about three-dimensional bodies of arbitrary shape. This report describes the velocity potential code.

In particular, the DTNSRDC version of the XYZPF is a computer program, written in FORTRAN, which utilizes a surface source density distribution on the surface of the body to compute the irrotational, incompressible potential flow about three-dimensional arbitrary shaped bodies. The body

surface is approximated by a set of plane quadrilaterals with a corresponding set of Fredholm integral equations of the second kind to solve for the source density on each quadrilateral. The equations are approximated by (1) assuming that the source density is constant in each quadrilateral, and (2) by applying the boundary condition (normal component of velocity is zero for a uniform onset flow) at only one point in the quadrilateral, the centroid. Once the set of equations is solved for the source density distribution, the flow velocity at on- and off-body points is calculated. Velocities are calculated for the three unit translational onflows and any other onflow specified by the user. This code was installed on a CDC 6700 computer.

The DTNSRDC version of XYZPF was supplied to NUSC by the Navy Engineering Software Systems (NESS) and was used as the basis for the NUSC version of the program. The NUSC version described in this report has been written to fit on a PDP 11/34 minicomputer and has the increased capability of calculating the perturbation and total velocity potentials at points on and off the body. In addition, programs were created to perform calculations for body motion with two rotational degrees of freedom, q and r.

Previously, difficulties in using the XYZPF were the tediousness and excessive time requirements involved in the task of generating the surface grid which is used as input to the program to define the surface of the body. This task has been facilitated by the use of a finite element mesh generator. The mesh generator used at NUSC has been SUPERTAB, a product of Structural Dynamics Research Corporation. An additional benefit of using

this interactive graphics mesh generator is the use of its visual display of the grid as an error check.

A post-processor has been written which converts the node point numbering scheme of SUPERTAB to that required by XYZPF. This is described further in the "Grid Generator" section of this report.

2.0 THEORETICAL CONSIDERATIONS

2.1 VELOCITY POTENTIAL AND BOUNDARY CONDITIONS

The total velocity potential (ϕ) was calculated as the sum of the perturbation potential (ϕ_p) due to the presence of the body and the potential (ϕ_∞) due to the onflow:

$$\phi = \phi_p + \phi_\infty$$

where $\phi_\infty = -(V_{\infty_X} X + V_{\infty_Y} Y + V_{\infty_Z} Z)$ For translational D.O.F.

$\phi_\infty = 0$ For rotational D.O.F.

where X, Y, Z are Cartesian coordinates of a point in the flow field.

$V_{\infty_X}, V_{\infty_Y}, V_{\infty_Z}$ are the three components of flow field velocity at infinity.

The surface boundary condition for translational onflow is identical in the DTNSRDC and NUSC versions of XYZPF. The program assumes the body is

stationary and values are computed separately for unit onflow in the negative direction of the X, Y, and Z axes. The surface boundary condition for this case is that the normal component of velocity on the surface is zero, i.e.:

$$\left(\frac{\partial\phi}{\partial n}\right)_s = \vec{n} \cdot \nabla\phi = 0 \qquad \text{TRANSLATION B.C.}$$

where $\vec{n}$ is the unit outward normal vector, and ∇ is the gradient.

For the case of rotational motion of the body, the onset flow is ro and the body is rotating with unit angular velocity in the positive direction (right-hand coordinate system). The surface boundary cond· .ʼ therefore, requires the normal velocity of flow on the surface to equal the normal velocity of the surface at that point, i.e.:

$$\left(\frac{\partial\phi}{\partial n}\right)_s = \vec{n} \cdot \nabla\phi = \vec{n} \cdot (\vec{\omega} \times \vec{R}) \qquad \text{ROTATIONAL B.C.}$$

where $\vec{\omega}$ is the angular velocity vector of the body and $\vec{R}$ is the directional vector from the center of gravity (C.G.) of the body to the point on the surface.

It should be noted that the translation of a body in the positive direction of a stationary flow field perturbs the fluid in the same manner as a stationary body in a uniform onflow in the negative direction. Therefore, perturbation velocity potentials calculated in XYZPF for uniform onflow in the negative direction are identical to the total velocity potentials of a body moving in the positive direction of a stationary flow field.

The perturbation velocity potential (ϕ_p) is evaluated by one of three methods depending upon the ratio (X/T) of the distance (X) between the point under consideration and the centroid of the quadrilateral to the maximum dimension (T) of the quadrilateral. This approach, utilizing three ranges, is consistent with the remainder of the program where integral equations for the source density were evaluated using the same criteria. As stated in reference 1, the criteria is: "If the ratio (X/T) is greater than 4.0, the quadrilateral is approximated by a monopole (as if it were concentrated at one point). If the ratio is greater than 2.0 and less than or equal to 4.0, the quadrilateral is approximated by a quadrupole. If the ratio is less than or equal to 2.0, the integrals are evaluated exactly. The approximate methods are used because they require much less time than the exact method."

The perturbation velocity potential equations for each range were derived in reference 2. The resulting equations using the terminology of XYZPFP and rearranged to facilitate computations are:

Exact: $$\phi_p = - \ (PR12)(CLA1) + (PR23)(CLA2) + (PR34)(CLA3) + (PR41)(CLA4) + (Z)(TVZ)$$

Quadrupole: $$\phi_p = (A)(W) - (CIXX)(WXX) + (CIXY)(WXY) - (CIYY)(WYY)$$

Monopole: $$\phi_p = (A)(W)$$
$$W = 1/ \ X^2 + Y^2 + Z^2 \ ^{1/2}$$

where: A = Area of quadrilateral

CIXX, CIXY, CIYY = Moments of inertia about the origin of the quadrilateral

CLA1, CLA2, CLA3, CLA4 = Coefficients calculated in XYZPFP

PR12, PR23, PR34, PR41 = Signed perpendicular distance of the point from the extension of a side of the quadrilateral (in quadrilateral coordinate system).

WXX $= \dfrac{\partial^2 W}{\partial X^2}$

WXY $= \dfrac{\partial^2 W}{\partial X \partial Y}$

WYY $= \dfrac{\partial^2 W}{\partial Y^2}$

X, Y, Z = location of point in quadrilateral coordinate system

TVZ = Z component of induced velocity

To validate the applicable range of each formula, comparisons were made between velocity potentials computed by the exact and approximate formulas for a square quadrilateral having unit source density.

Results are shown in figure 1 where velocity potential is plotted versus nondimensionalized normal distance from the plane of the quadrilateral. With the exact formula as a baseline, it is evident that, for a square quadrilateral, the monopole and quadrupole approximations are highly accurate. The two approximate methods converge to the exact at the non-dimensionalized (X/T) distance of approximately 1.4, considerably closer

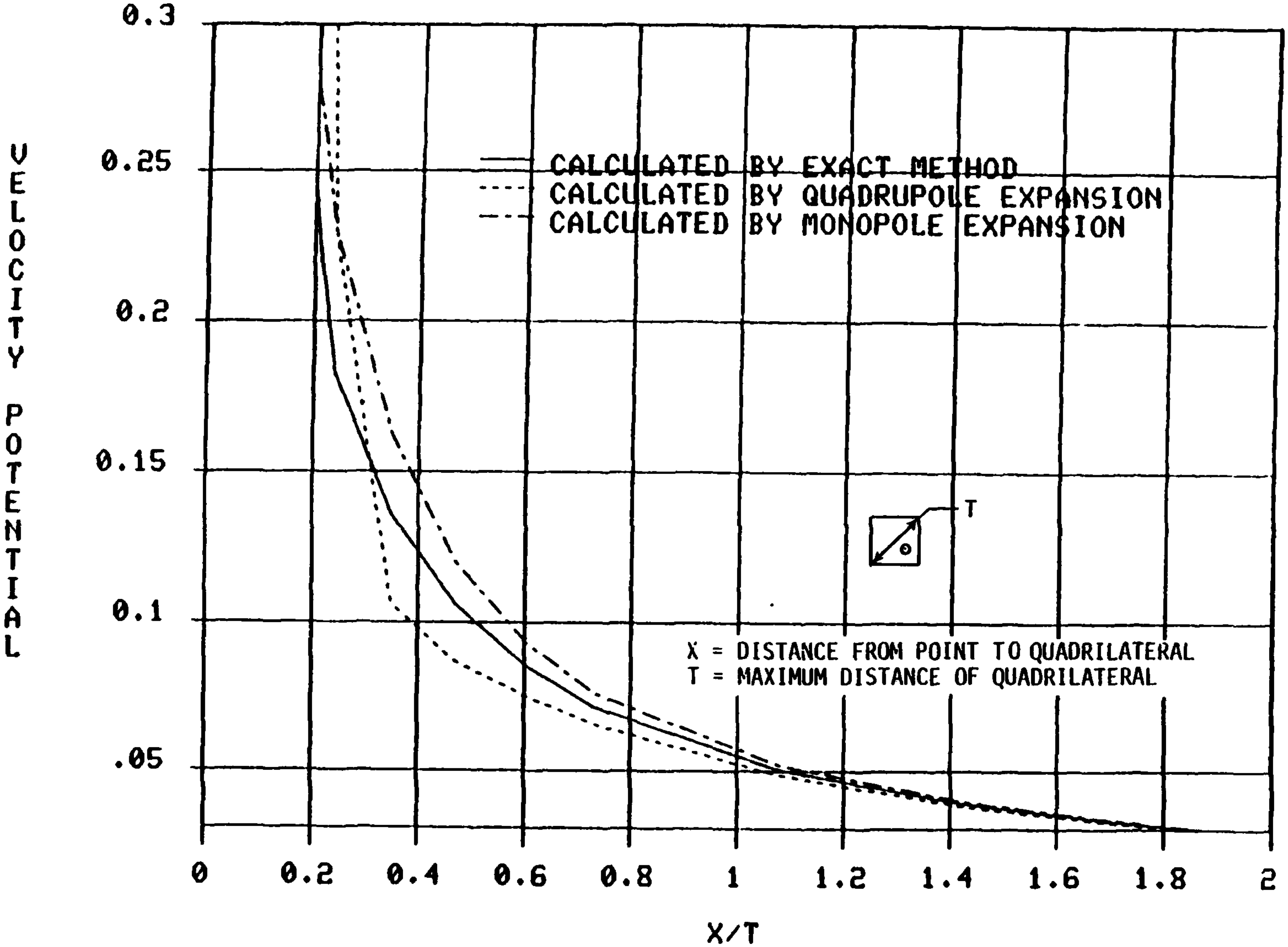

Figure 1. Effect of Quadrupole and Monopole Approximations on Velocity Potential Calculations

than the range in which each approximation is used. Even with these excellent results, the range criteria previously stated was not changed. The reasons were to remain consistent with the ranges used for other calculations and to be conservative since quadrilaterals of other shapes may not give rise to approximate values with the same degree of convergence as the square quadrilateral.

The translation D.O.F. programs automatically calculate and output values of velocities and velocity potentials for the three unit flows in the negative direction. In addition, the user may specify the vector of other flows to be considered.

Similarly, the rotational D.O.F. programs also automatically calculate and output values of velocities and velocity potentials for unit body motion in the positive direction for both rotational degrees of freedom. However, no provision for calculations of additional flows has been included. Additional flows were intentionally not included since it is a simple matter to calculate them from the unit flows.

Since velocity potentials of each unit flow are linearly independent, the total velocity potential for a five degree-of-freedom flow becomes:

$$\phi = u\phi_u + v\phi_v + w\phi_w + q\phi_q + r\phi_r$$

where u, v, w, q, r are the actual velocity components

and $\phi_u, \phi_v, \phi_w, \phi_q, \phi_r$ are the unit velocity potentials for each D.O.F.

2.2 SYMMETRY CONSIDERATIONS

The translational D.O.F. XYZPF has the feature that only nonsymmetrical parts of the surface have to be defined. This feature capitalizes on the fact that for uniform onflows, geometrically symmetric quadrilaterals about a plane have source densities equal in magnitude. However, the sign of a reflected quadrilateral is a function of the plane about which it is reflected and also the direction of motion of the body or onflow.

For rotational motion of the body, the symmetry feature is only applicable when the C.G. and centroid of the body coincide. This constraint is imposed because this is the only condition where source densities of geometrically symmetric quadrilaterals are equal in magnitude. This is a consequence of the boundary condition being a function of the displacement vector $\vec{R}$ between the C.G. and the quadrilateral. If the magnitude of $\vec{R}$ varies between geometrically symmetric quadrilaterals, then the magnitude of the boundary condition will vary, resulting in unequal source densities. In this case, the complete body will have to be defined.

3.0 GRID GENERATOR

As mentioned in the introduction, the tediousness and excessive time requirements of manually generating the surface grid of the body have been overcome by utilizing a finite element mesh generator. Figure 2 is a typical grid generated with the use of SUPERTAB. Since the body is symmetric, only one-quarter of the body has been defined and is represented by those points connected with lines. The remaining points are a reflection

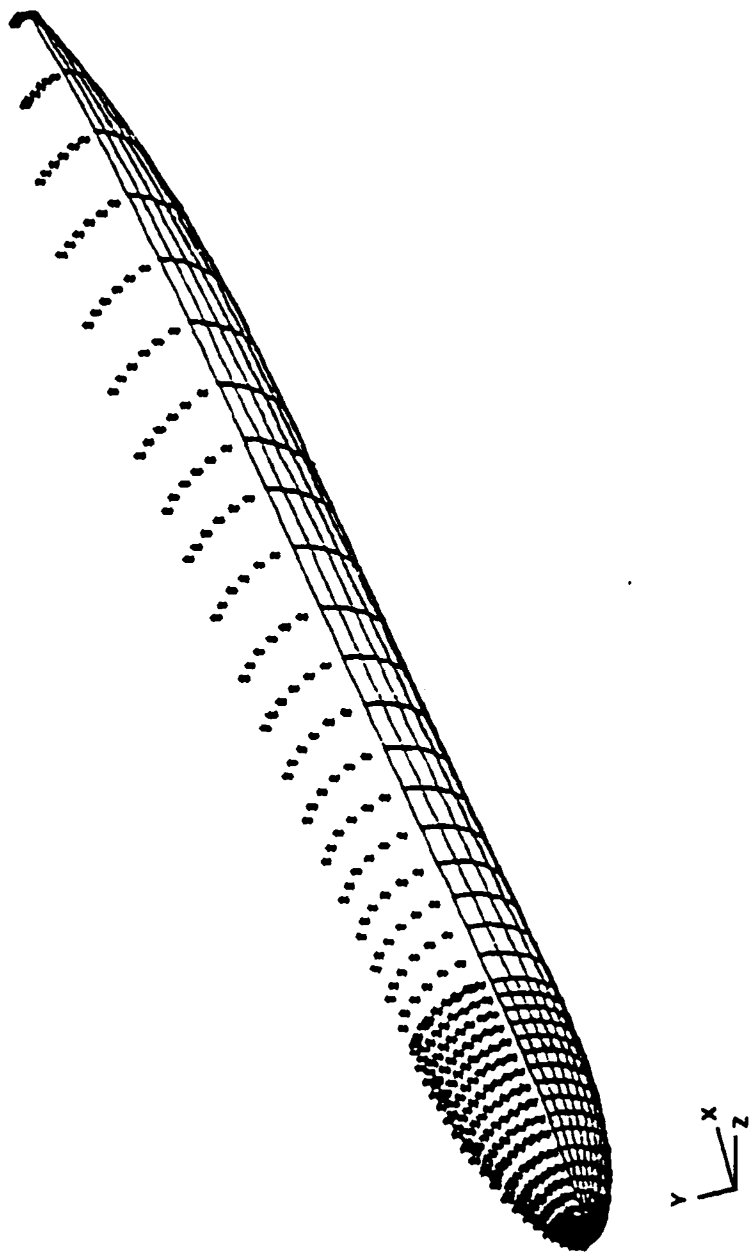

Figure 2. XYZPF Grid Generated with a Finite Element Mesh Generator

of the basic points and are displayed only as an aid to visualize the body shape.

Since SUPERTAB has a consecutive node numbering scheme with only one indice per node and the XYZPFP requires a two-indice per node numbering scheme, a post-processor called XYZIN.FTN was written to accommodate the change. The program is run interactively and requests information as needed.

Appendix A contains the program listing. Instructions on its use are contained in the comment statements of the program and are self explanatory.

4.0 PROGRAM STRUCTURE

The NUSC version of XYZPFP has been rewritten to fit on a PDP 11/34A minicomputer as opposed to a mainframe CDC 6700 computer for which DTNSRDC's version was written.

The distribution of calculations into seven separate programs remains the same in both versions. The first three programs calculate quadrilateral geometric data and source densities. Program 4 calculates values of velocity and velocity potential for on-body points while program 5 performs similar calculations for off-body points. The sixth and seventh programs calculate off-body and on-body streamlines, respectively, for translational motion only.

The seven programs for the translational D.O.F. are named PFP1.FTN through PFP7.FTN. The five programs for the rotational D.O.F. are named RPFP1.FTN through RPFP5.FTN. Programs for the translational D.O.F. are independent of the rotational D.O.F. programs and must be run separately.

In any case, the first four programs must be executed initially to generate geometric parameters and calculate source densities. These data are then saved in three files which are subsequently used when the remaining programs are executed. The remaining programs can be run in any combination and may be executed in the same run as the first four programs or later during a separate run.

The files created during execution of the first four programs are named UNIT3.DAT, UNIT4.DAT and POTFILE.DAT by the program. These files are necessary to execute programs 5 through 7 and are the default names for the files called by these programs. In order to manage these files, they can be appropriately renamed. As discussed in the next section, these non-default file names can be specified as the files to be called by the programs. Since the translational and rotational D.O.F. programs are separate programs, the contents of the files will be different. To avoid confusion, care should be taken when renaming the files.

5.0 ORGANIZATION OF INPUT DATA

Input data for the NUSC version of XYZPF is via a computer file. The input format is basically the same in both the NUSC and DTNSRDC versions, therefore, the input description in reference 1 is repeated here but with the changes required for the NUSC version.

The format for a new job starting from program 1 is:

1st Line: RESTART - Typed in columns 1 to 7

FLAG 1 - 0 or 1 in column 19

0 - specifies a new job starting from Program 1

1 - specifies a restart job with Programs 1 through 4 previously run

FLAG 2 - 0 or 1 in column 21

0 - specifies default file names are used

1 - specifies non-default file names are used

When Flag 2 on line 1 is 1 (non-default file names) the three renamed file names are listed on the next three lines in the order:

UNIT3.DAT renamed

UNIT4.DAT renamed

POTFILE.DAT renamed.

The next line is for identification. It contains information to identify the problem in columns 2 to 60.

The parameter line is next and contains the following information in the order given. The FORTRAN format for this line is (6I4, F8.4, 3I4).

NQE is the number of quadrilateral elements to be specified by the point lines. NQE must be in columns 2, 3, and 4 and as far to the right as possible. The maximum value permitted for NQE is 650.

NSE is the number of sections used. NSE must be in columns 6, 7, and 8 and as far to the right as possible.

MIX is the maximum number of iterations to be performed for the X or Q flow. MIX must be in columns 10, 11, 12 and must be as far to the right as possible. MIX must be less than 200.

MIY is the maximum number of iterations for the Y or R flow. MIY must be in columns 14, 15, 16 and must be as far to the right as possible. MIY must be less than 200.

MIZ is the maximum number of iterations for the Z flow. MIZ must be in columns 18, 19, 20 and must be as far to the right as possible. MIZ must be less than 200. MIZ is read in during a rotational D.O.F. run but can have any value since it is not used during the run.

ISM is the number of planes of symmetry.

ISM = 0 indicates there are no planes of symmetry.

ISM = 1 indicates that Y=0 is a plane of symmetry.

ISM = 2 indicates that Y=0 and Z=0 are planes of symmetry.

ISM = 3 indicates that Y=0, Z=0 and X=0 are planes of symmetry.

ISM must be in column 24.

EPS is the convergence criteria used in testing the convergence of the iterations. EPS must be in columns 25 through 32 and should include the decimal point.

The next line contains the X, Y, Z coordinates for the center of gravity. The format is 3F10.4.

Lines containing information for the grid points follow. Each line has the format (3F12.9, 4I4, F12.9) and contains the following information for one point on the surface. See reference 1 for grid requirements.

XI — is the X-coordinate of the point and must be in columns 1 through 12.

YI — is the Y-coordinate of the point and must be in columns 13 through 24.

ZI — is the Z-coordinate of the point and must be in columns 25 through 36.

NI — is the N index for the point. NI must be less than 71 and must be in columns 39 and 40.

MI — is the M index for the point. MI must be less than 41 and must be in columns 43 and 44.

NS — is the section identification number. NS may be any positive integer from 1 to 9999 and must be in columns 45 through 48. NS must be different for different sections.

NE — is used to change the direction of the normal vector. When NE in the first line of a section is not blank or zero, NI and MI are interchanged for that section. On the other cards, NE is ignored. Column 52 is used for NE.

VN — is the normal component of the velocity at the body surface. Most problems have VN equal to zero. For some problems, such as inlet pipes, it is desirable to have a nonzero VN on some sections of the input. The value of VN from the first card in a section is used for the entire section. Columns 53 through 64 are used for VN.

All point lines for one section must be together, but within the section they may be in any order.

Additional flows are calculated only for the translation D.O.F. programs. Lines for additional flows to be edited follow the last point line for the last section. A maximum of 18 flows may be edited. The format for these lines is (3F12.9). On each line are specified the three components of the free-stream velocity for one flow as shown below.

VXI is the X-component and must be in columns 1 through 12.

VYI is the Y-component and must be in columns 13 through 24.

VZI is the Z-component and must be in columns 25 through 36.

This is all the information which is required to run the first four programs.

The input file format for programs 5 through 7 is identical to the DTNSRDC version except that an additional line which specifies the program to be executed is required. This line immediately precedes the standard input data for that program and consists of the word SEGMENT5, SEGMENT6, or SEGMENT7 (starting in column 1) depending on whether the program to be executed next is for program 5, program 6, or program 7, respectively. This completes the input data file for a new job starting from program 1.

When the job to be run is a restart job where programs 1 through 4 have already been executed, the input data file has the structure of a new job data file except the following lines are excluded:

Identification line

Parameter line

Line with C.G. data

Grid point lines

Additional flow lines

Appendix B lists two input files for the sample case of a sphere (the same sample as presented in reference 1) with a radius equal to 1, a coarse grid of 12 quadrilaterals and using three planes of symmetry (see figure 3). The first file is the case where programs 1 through 5 are run successively, while the second is for the restart case where only program 5 is run.

6.0 EXECUTING THE PROGRAMS

To execute the programs, the task (.TSK) files for each of the PFP and RPFP programs must be accessible. In addition, the following files must also be accessible: XYZ.CMD, XYZ.TSK, CREATE.TSK, and XYZSUB.OLB. These latter programs control execution of the PFP and RPFP programs and contain required subroutines.

The procedure for executing a new job or a restart job is identical. The procedure is simple and straightforward as evidenced in the sample of figure 4. The job is run interactively on the terminal via a command file. To initiate the job, the operator types "@XYZ" into the terminal. The computer responds by asking whether the translational or rotational programs are to be executed, and the operator answers with a "T" or "R" specifying translational or rotational, respectively. The computer next asks for the input data filename and, lastly, the filename to which the output will be written. This is all that is required of the operator.

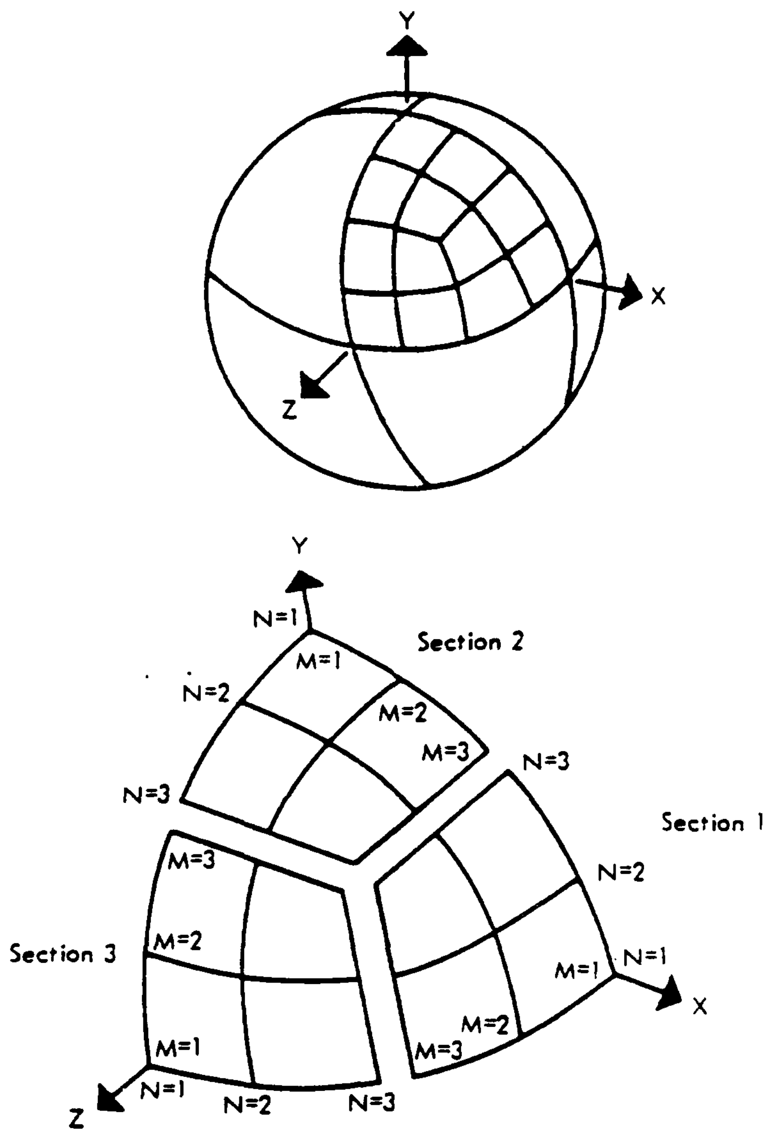

Figure 3. Representation of a Sphere (from Ref. 1)

```
[@XYZ]
> DO YOU WANT TO RUN TRANSLATIONAL OR ROTATIONAL XYZ (T OR R) [S]: [T]
******************************************************
*                                                    *
*       TRANSLATIONAL DEGREES OF FREEDOM             *
*                                                    *
*  XYZ POTENTIAL FLOW PROGRAM - PDP 11/34 VERSION    *
*                                                    *
*   PROGRAM IS LIMITED TO 650 QUADS AND 120 OFF      *
*   BODY POINTS WITH 50 OFF BODY STREAMLINES AND     *
*   50 ON-BODY STREAMLINES. PLEASE REPORT ANY        *
*   PROBLEMS WHICH OCCUR WITH RESULTS OR DURING      *
*   EXECUTION. CAUTION ! - THIS PROGRAM USES A       *
*   LARGE AMOUNT OF DISK SPACE, IF YOU ARE GOING     *
*   TO RUN A LARGE JOB IT MIGHT BE ADVISABLE TO      *
*   SEE YOUR SYSTEMS PEOPLE AND HAVE A BLANK DISK    *
*   ASSIGNED TO THE JOB.                             *
*                                                    *
******************************************************

 ENTER FILE NAME CONTAINING THE INPUT DATA
[SPHERE.DAT]

 ENTER FILE NAME TO WHICH YOU WANT THE OUTPUT TO GO
[SPHERE.OUT]

TT1  --  STOP END OF XYZ CREATION PHASE
TT1  --  STOP END OF PFP1
TT1  --  STOP END OF PFP2
TT1  --  STOP END OF PFP3
TT1  --  STOP END OF PFP4
TT1  --  STOP END OF SEGMENT 5
TT1  --  STOP SEGMENT 6 NOT RUN
TT1  --  STOP NO SCRATCH FILES CREATED FOR SECTION 7
TT1  --  STOP SEGMENT 7 NOT RUN
>@ <EOF>
>
```

NOTE: ITEM IN BLOCKS ARE INPUT BY OPERATOR.

Figure 4. Program Execution Procedure

If a program is not being executed, the computer acknowledges this and notifies the operator via the terminal. If a program is executed, the computer makes acknowledgement upon completion via the terminal.

A file called FILENAMES.DAT, created during the execution of the programs, remains in the user's directory at the end of the job. This file is useful only during the execution of the immediate job and may be deleted upon completion of the job. A new file is automatically created at the beginning of each new and restart job.

7.0 OUTPUT

The sample case of the sphere with a radius equal to 1 was run for both the translational and rotational XYZPF programs. The output listings are presented in appendix C.

Output from the translational programs are similar to the DTNSRDC version except for the addition of total and perturbation velocity potentials for each on- and off-body point. A similar output listing is also generated for the rotational D.O.F. calculations. However, since the total velocity potential equals the perturbation velocity potential, only one value is given. The output table from the rotational programs also differs in that pressure coefficient (CP) is not given for the rotational D.O.F. This is because pressure coefficient, as calculated in the translational D.O.F. programs, is not applicable to the rotational case.

8.0 RESULTS

Results of velocity potential calculations for the sample case of the sphere in a uniform stream is presented in figure 5. It is evident that even though this sample has a coarse grid, excellent results were obtained.

A second sample was run using a 2:1 ellipsoid. Since this body is symmetric about three planes, only one-eighth of the body was modeled. A coarse grid of only 32 quadrilaterals was chosen.

Figures 6 through 8 present results for two translational onflows and one rotational motion of the ellipsoid. Again, as with the sphere example, excellent results were obtained.

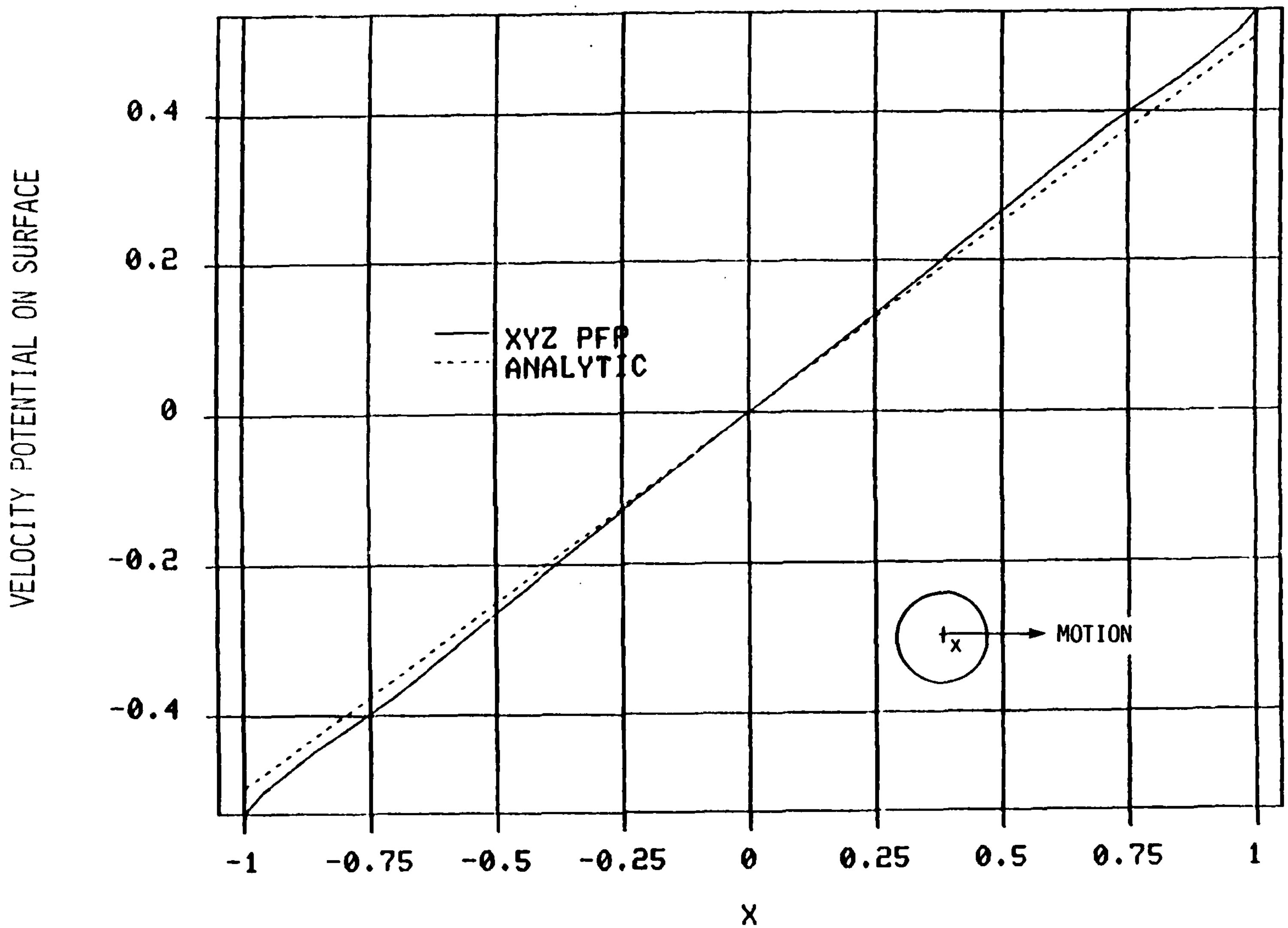

Figure 5. Sphere (Radius = 1) Moving in a Stationary Fluid

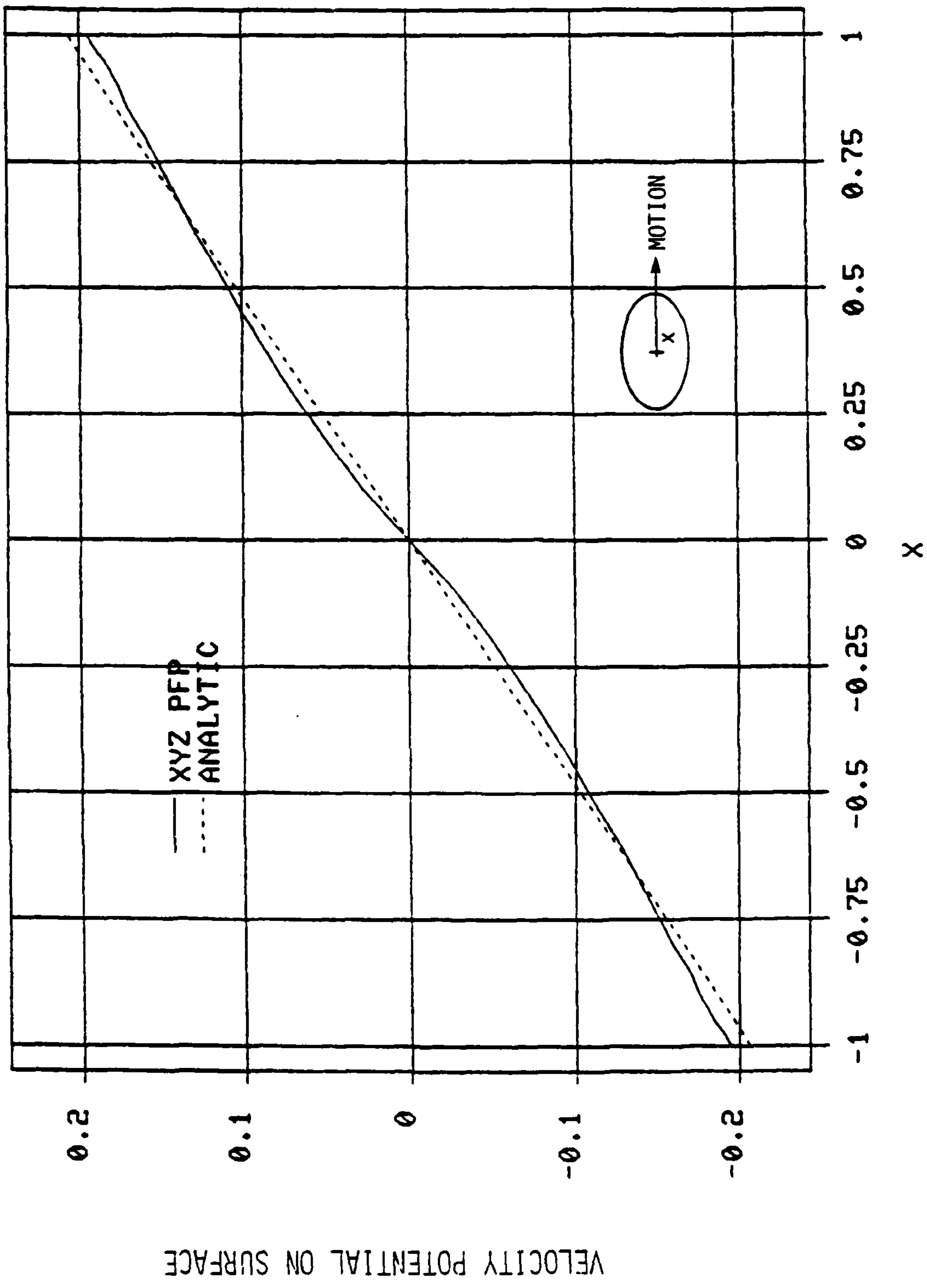

Figure 6. 2:1 Ellipsoid - End-on Motion.

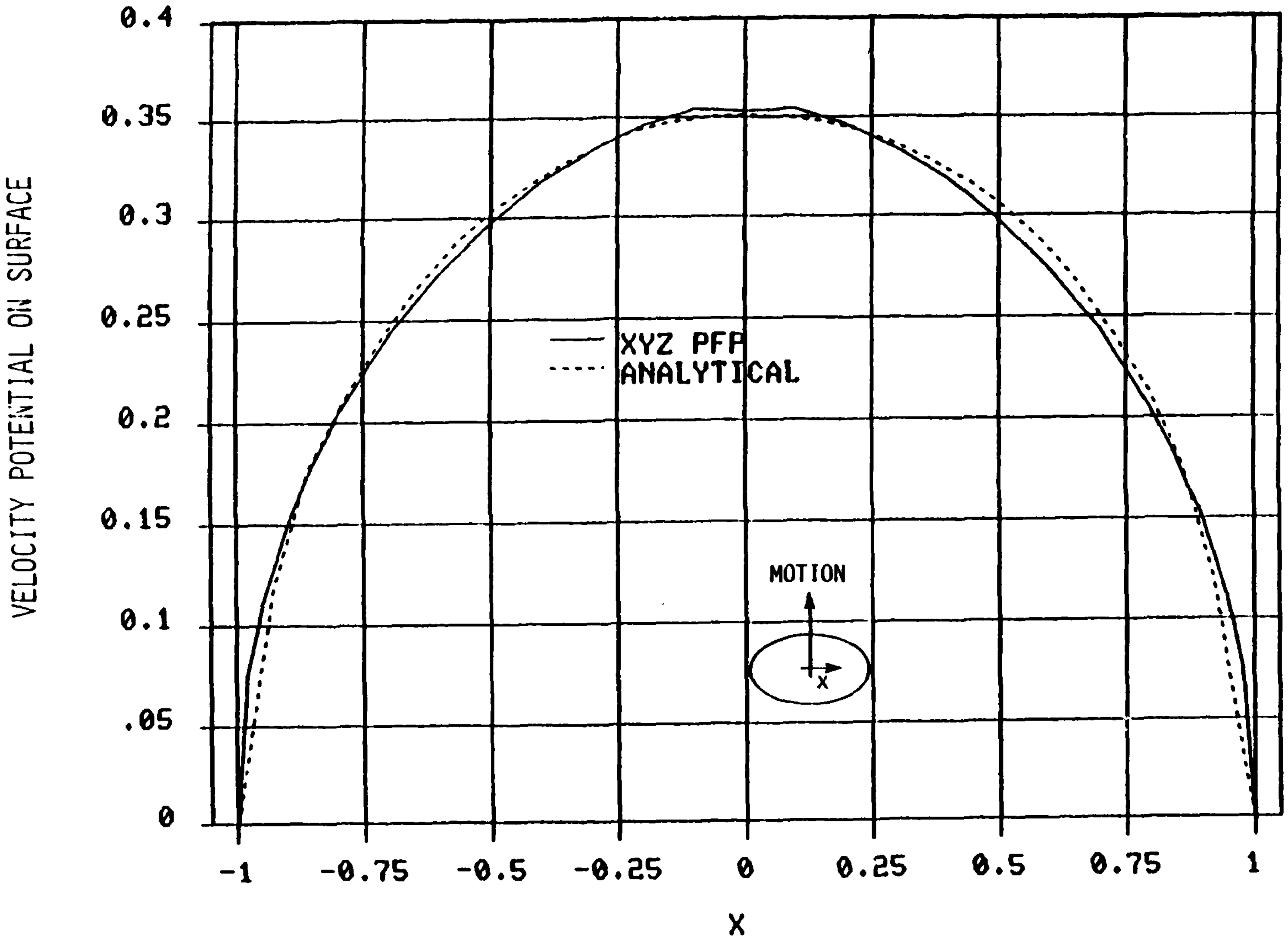

Figure 7. 2:1 Ellipsoid - Broadside Motion

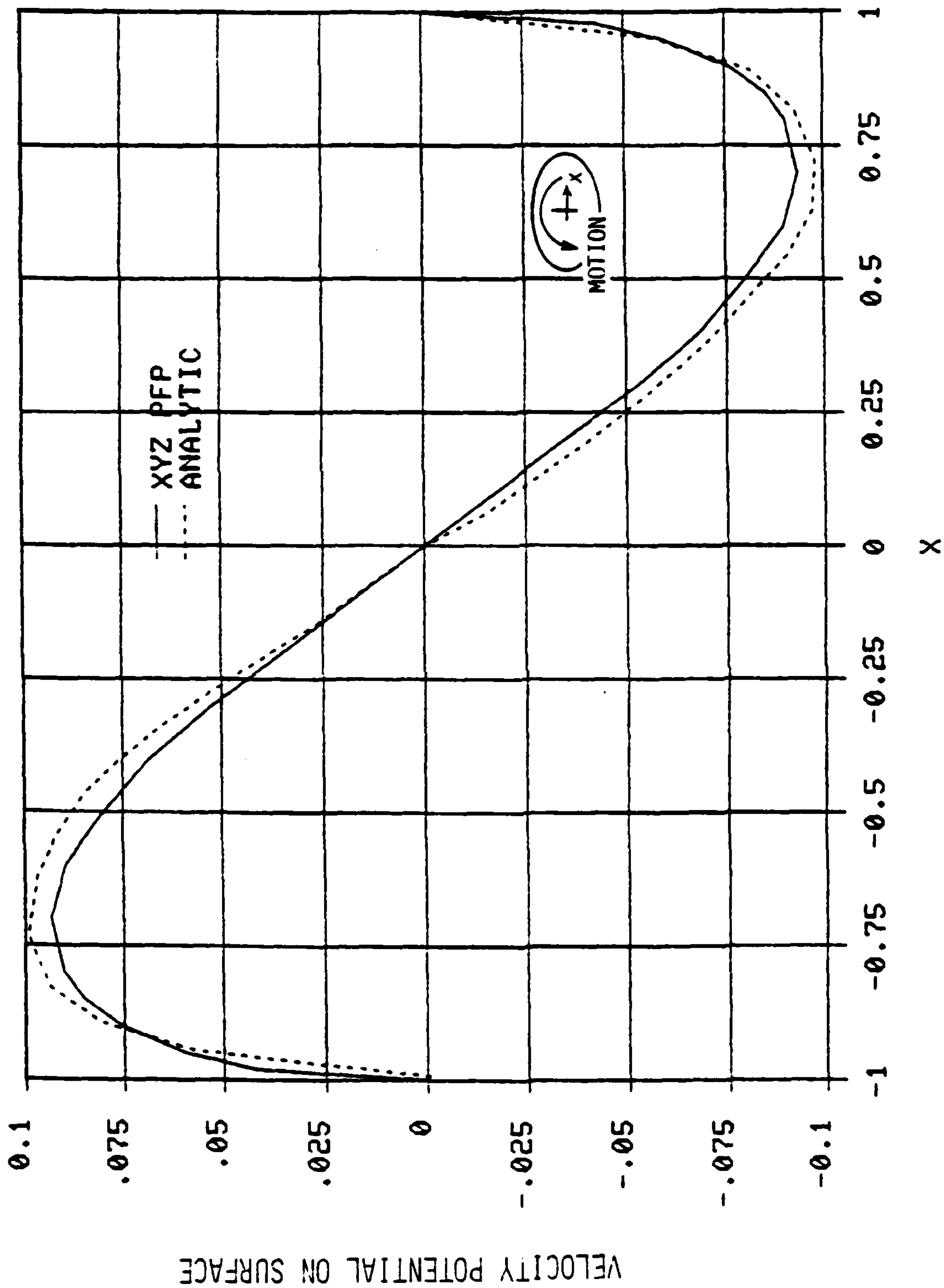

Figure 8. 2:1 Ellipsoid - Rotational Motion

9.0 REFERENCES

1. Dawson, C. W., and Dean, J. S., "The XYZ Potential Flow Program," Naval Ship Research and Development Center, NSRDC Report 3892, June 1972.

2. Hess, J. L., and Smith, A. M. U., "Calculation of Potential Flow About Arbitrary Bodies," Progress in Aeronautical Sciences, Vol. 8, 1966.

3. Kellogg, O. D., Foundations of Potential Theory, Frederick Ungar Publishing Company, 1929, also available through Dover Publishings, Inc.

APPENDIX A

GRID GENERATOR POST-PROCESSOR

COMPUTER LISTING

```
C          XYZIN.FTN  (COMPATIBLE WITH PDP 11/34)
C
C       THIS PROGRAM REARRANGES THE OUTPUT(UNIVERSAL) FILE OF
C       PROGRAM 'SUPERTAB' (A FINITE ELEMENT MESH GENERATOR)
C       INTO A FORMAT ACCEPTABLE FOR
C       INPUT INTO 'XYZPFP' (XYZ POTENTIAL FLOW PROGRAM).
C       THIS PROGRAM IS RUN INTERACTIVELY ON A TERMINAL.
C
C       WHEN GENERATING THE MESH WITH SUPERTAB, THE MODEL MAY BE SEPARATED
C       INTO SECTIONS AS ALLOWED BY "XYZPFP." THE UNIVERSAL FILE MUST BE
C       EDITED SO THAT ONLY LINES WITH NODE DATA ARE PRESENT.
C
C       FOR EACH SECTION TO BE FORMATTED, THE PROGRAM ASKS FIRST FOR
C       THE SECTION NUMBER TO BE ASSIGNED.  REQUESTED NEXT IS THE RANGE
C       OF NODE POINTS TO BE INCLUDED IN THE SECTION.  LASTLY, THE
C       COMPUTER ASKS FOR THE MAXIMUM VALUES OF THE "N" AND "M"
C       INDICES.   THE FIRST NODE POINT ENCOUNTERED WITHIN THE
C       ACCEPTABLE RANGE IS GIVEN THE INDICES N=1 AND M=1.
C       FOR SUBSEQUENT NODES, N IS INDEXED BY ONE UNTIL "N" MAXIMUM
C       IS ASSIGNED.  THEN "M" IS INDEXED BY ONE AND "N" VALUES ARE
C       AGAIN REPEATED FROM ONE TO "N" MAXIMUM.
C
C       WHEN GENERATING THE MESH WITH SUPERTAB, THE USER SHOULD
C       BE CAUTIOUS THAT THE NODES ARE INITIALLY NUMBERED IN THE
C       CORRECT DIRECTION TO GIVE A RIGHT HANDED COORDINATE SYSTEM
C       UPON REFORMATTING.
C
C       DATA IS OUTPUT TO THE FILE ONLY AFTER IT HAS BEEN
C       DETERMINED THAT THE DATA FOR THAT SECTION HAS BEEN
C       CORRECTLY READ IN.
C
C       ARRAYS ARE DIMENSIONED TO ACCEPT SECTIONS WITH
C       VALUES OF MAXIMUM N*M WHICH ARE NOT GREATER THAN 1000.
C       FOR SECTIONS WITH N*M GREATER THAN 1000, THE ARRAYS WILL
C       HAVE TO BE INCREASED TO THE N*M VALUE.
C
C
C
      DIMENSION X(1000),Y(1000),Z(1000),NVAR(1000),FILEIN(14),
     1FILEOU(14),MVAR(1000)
      BYTE ANS
10    FORMAT(14A1)
20    FORMAT(4I10,3E13.5)
30    FORMAT(2I5)
40    FORMAT(I5)
50    FORMAT(A1)
60    FORMAT(3F12.5,3I4)
      TYPE *,'TYPE INPUT DATA FILENAME  E.G. FILENAME.DAT'
      ACCEPT 10,FILEIN
      FILEIN(14)=0
      TYPE *,'TYPE OUTPUT DATA FILENAME'
      ACCEPT 10,FILEOU
      FILEOU(14)=0
      OPEN(UNIT=1,NAME=FILEIN,FORM='FORMATTED',TYPE='OLD',
     1READONLY)
      OPEN(UNIT=2,NAME=FILEOU,TYPE='NEW',FORM='FORMATTED',
     1CARRIAGECONTROL='LIST')
      GO TO 300
200   TYPE *,'DO YOU WANT TO SET UP ANOTHER SECTION? Y/N'
      ACCEPT 50,ANS
      IF(ANS.EQ.'N')GO TO 9999
      REWIND 1
```

```
300   TYPE *,'TYPE SECTION NUMBER'
      ACCEPT 40,NSECT
      TYPE *,'TYPE NUMBERS WHICH DESIGNATE THE RANGE OF
     1 NODE POINTS TO BE INCLUDED IN THIS SECTION
     2 I.E. MINIMUM PT.,MAXIMUM PT.'
      ACCEPT 30, LMIN,LMAX
      TYPE *,'TYPE MAXIMUM N AND M VALUES:I.E. N,M'
      ACCEPT 30,N,M
      NVARR=0
      MVARR=1
      J=0
1000  READ(1,20,END=3000)I,I1,I2,I3,XX,YY,ZZ
      IF(I.LT.LMIN .OR. I.GT.LMAX) GO TO 1000
      IF(NVARR.EQ.N)GO TO 1500
      NVARR=NVARR+1
      GO TO 1600
1500  MVARR=MVARR+1
      NVARR=1
1600  J=J+1
      X(J)=XX
      Y(J)=YY
      Z(J)=ZZ
      NVAR(J)=NVARR
      MVAR(J)=MVARR
      GO TO 1000
3000  CONTINUE
      IF(N.NE.NVARR)GO TO 4000
      IF(M.NE.MVARR)GO TO 4000
      WRITE (2,60)(X(K),Y(K),Z(K),NVAR(K),MVAR(K),NSECT,K=1,J)
      TYPE *,'DATA READ IN CORRECTLY'
      GO TO 200
4000  TYPE *,'ERROR - DATA NOT READ IN CORRECTLY'
      GO TU 200
9999  STOP
      END
```

APPENDIX B

INPUT FILES FOR SPHERE SAMPLE

SPHERE INPUT FILE TO EXECUTE PROGRAMS 1 THROUGH 5

```
RESTART
        SAMPLE PROBLEM   SPHERE
 12   3 150 150 150   3  .0001
  0.0, 0.0, 0.0
  1.0         .0          .0          1   1   1
   .92388     .0          .38268      1   2   1
   .70711     .0          .70711      1   3   1
   .92388     .38268      .0          2   1   1
   .88808     .32504      .32504      2   2   1
   .67383     .30320      .67383      2   3   1
   .70711     .70711      .0          3   1   1
   .67383     .67383      .30320      3   2   1
   .57735     .57735      .57735      3   3   1
   .0        1.0          .0          1   1   2
   .38268     .92388      .0          1   2   2
   .70711     .70711      .0          1   3   2
   .0         .92388      .38268      2   1   2
   .32504     .88808      .32504      2   2   2
   .67383     .67383      .30320      2   3   2
   .0         .70711      .70711      3   1   2
   .30320     .67383      .67383      3   2   2
   .57735     .57735      .57735      3   3   2
   .0         .0         1.0          1   1   3
   .0         .38269      .92388      1   2   3
   .0         .70711      .70711      1   3   3
   .38268     .0          .92388      2   1   3
   .32504     .32504      .88808      2   2   3
   .30320     .67383      .67383      2   3   3
   .70711     .0          .70711      3   1   3
   .67383     .30320      .67383      3   2   3
   .57735     .57735      .57735      3   3   3
   .57735     .57735      .57735
   .70711     .0          .70711
SEGMENTS
  4
     .999        .889        .777
   15.0         0.         -1.0
   -2.0         3.0         0.0
    0.0         0.0         2.0
```

SPHERE INPUT FILE TO EXECUTE PROGRAM 5 AS A RESTART JOB

```
RESTART          1 1
ROUNIT3.DAT
ROUNIT4.DAT
RPOTFIL.DAT
SEGMENTS
  4
      .999          .888       .777
    15.0          0.         -1.0
    -2.0          3.0         0.0
     0.0          0.0         2.0
```

APPENDIX C

OUTPUT LISTING - SPHERE SAMPLE

TRANSLATIONAL D.O.F. SAMPLE

```
XYZ POTENTIAL FLOW PROGRAM SECTION 1, VERSION 4

DATE: 22-APR-82          SUBROUTINE START TIME 14:10:52

        SAMPLE PROBLEM    SPHERE

NO. OF QUADS.  =  12
NO. OF SECTIONS=   3
MAX. NO. OF ITERATIONS X FLOW 150   Y FLOW 150   Z FLOW 150
3 PLANES OF SYMMETRY

CONVERGENCE CRITERIA , 0.00010

   ISP =  0

IEDIT1 =  0
IEDIT3 =  0
IEDIT4 =  0
ITAPE  =  0

XCENTER = 0.00
YCENTER = 0.00
ZCENTER = 0.00
```

SECTION 1

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL C21	C24 C25 C26
1	0.10000E+01	0.92388E+00	0.88309E+00	0.92388E+00	0.33409E+00	0.30748E+00	0.12402E+00	-0.55519E+00
1	0.00000E+00	0.00000E+00	0.32504E+00	0.38269E+00	0.17163E+00	0.17887E+00	0.27060E+00	-0.55328E+00
1	0.00000E+00	0.38269E+00	0.32504E+00	0.00000E+00	0.17163E+00	0.17887E+00	0.38023E-01	-0.11684E-01
1	0.92388E+00	0.98408E+00	0.67383E+00	0.70711E+00	0.80023E+00	0.34701E+00	0.12715E+00	-0.55116E+00
2	0.38268E+00	0.32504E+00	0.67383E+00	0.70711E+00	0.52041E+00	0.55792E+00	0.26663E+00	-0.55933E+00
2	0.00000E+00	0.32504E+00	0.30320E+00	0.00000E+00	0.15846E+00	0.60333E+00	0.35472E-01	0.53794E-02
2	0.92388E+00	0.70711E+00	0.67383E+00	0.88809E+00	0.80023E+00	0.34701E+00	0.12715E+00	-0.55845E+00
1	0.00000E+00	0.00000E+00	0.30320E+00	0.32504E+00	0.15846E+00	0.60339E+00	0.26663E+00	-0.55207E+00
3	0.38268E+00	0.70711E+00	0.67383E+00	0.32504E+00	0.52041E+00	0.55792E+00	0.35472E-01	0.74949E-02

QUESTIONABLE POINT -POOR FIT 0.749E-03

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL C21	C24 C25 C26
2	0.88309E+00	0.67383E+00	0.57735E+00	0.67383E+00	0.71067E+00	0.75490E+00	0.12400E+00	-0.55338E+00
2	0.32504E+00	0.30320E+00	0.57735E+00	0.67383E+00	0.46210E+00	0.47954E+00	0.26207E+00	-0.55115E+00
4	0.32504E+00	0.67383E+00	0.57735E+00	0.30320E+00	0.46210E+00	0.47954E+00	0.37339E-01	-0.11353E-01

SECTION 2

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL C21	C24 C25 C26
1	0.00000E+00	0.38268E+00	0.32504E+00	0.00000E+00	0.17163E+00	0.17887E+00	0.12402E+00	-0.55519E+00
1	0.10000E+01	0.92388E+00	0.88808E+00	0.92388E+00	0.33408E+00	0.30748E+00	0.27060E+00	-0.55328E+00
5	0.00000E+00	0.00000E+00	0.32504E+00	0.38268E+00	0.17163E+00	0.17887E+00	0.38023E-01	-0.11683E-01
1	0.00000E+00	0.32504E+00	0.30320E+00	0.00000E+00	0.15846E+00	0.60339E+00	0.12715E+00	-0.55114E+00
2	0.92388E+00	0.38309E+00	0.67383E+00	0.70711E+00	0.80023E+00	0.34701E+00	0.26663E+00	-0.55939E+00
6	0.38268E+00	0.32504E+00	0.67383E+00	0.70711E+00	0.52041E+00	0.55792E+00	0.35472E-01	0.53792E-02
2	0.38268E+00	0.70711E+00	0.67383E+00	0.32504E+00	0.52041E+00	0.55792E+00	0.12715E+00	-0.55345E+00
1	0.92388E+00	0.70711E+00	0.67383E+00	0.88308E+00	0.80023E+00	0.34701E+00	0.26563E+00	-0.55207E+00
7	0.00000E+00	0.00000E+00	0.30320E+00	0.32504E+00	0.15846E+00	0.60339E+00	0.35472E-01	0.74948E-02

QUESTIONABLE POINT -POOR FIT 0.749E-03

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL C21	C24 C25 C26
2	0.32504E+00	0.67383E+00	0.57735E+00	0.30320E+00	0.46210E+00	0.47954E+00	0.12400E+00	-0.55339E+00
2	0.88308E+00	0.67383E+00	0.57735E+00	0.67383E+00	0.71067E+00	0.75490E+00	0.26207E+00	-0.55116E+00
8	0.32504E+00	0.30320E+00	0.57735E+00	0.67383E+00	0.46210E+00	0.47954E+00	0.37339E-01	-0.11353E-01

SECTION 3

M / N / P	X1 / Y1 / Z1	X2 / Y2 / Z2	X3 / Y3 / Z3	X4 / Y4 / Z4	XP / YP / ZP	XN / YN / ZN	A / FL / CZ1	CZ4 / CZ5 / CZ6
1	0.00000E+00	0.00000E+00	0.32504E+00	0.38268E+00	0.17163E+00	[illegible]	0.12802E+00	-0.55513E+00
1	0.00000E+00	0.38268E+00	0.32504E+00	0.00000E+00	0.17163E+00	0.17987E+00	0.27060E+00	-0.55923E+00
9	0.10000E+01	0.92388E+00	0.88809E+00	0.92388E+00	0.33408E+00	[illegible]	0.38023E-01	-0.11584E-01
1	0.38268E+00	0.32504E+00	0.67383E+00	0.70711E+00	0.52041E+00	[illegible]	0.12715E+00	-0.55114E+00
2	0.00000E+00	0.32504E+00	0.30320E+00	0.00000E+00	0.15846E+00	[illegible]	0.26663E+00	-0.55339E+00
10	0.92388E+00	0.98808E+00	0.67383E+00	0.70711E+00	0.80023E+00	[illegible]	0.35472E-01	0.53793E-02
2	0.00000E+00	0.00000E+00	0.30320E+00	0.32504E+00	0.15846E+00	[illegible]	0.12715E+00	-0.55345E+00
1	0.38268E+00	0.70711E+00	0.67363E+00	0.32504E+00	0.52041E+00	[illegible]	0.26663E+00	-0.55207E+00
11	0.92388E+00	0.70711E+00	0.67383E+00	0.98808E+00	0.80023E+00	[illegible]	0.35472E-01	0.74347E-02

QUESTIONABLE POINT -POOR FIT 0.749E-03

M / N / P	X1 / Y1 / Z1	X2 / Y2 / Z2	X3 / Y3 / Z3	X4 / Y4 / Z4	XP / YP / ZP	XN / YN / ZN	A / FL / CZ1	CZ4 / CZ5 / CZ6
2	0.32504E+00	0.30320E+00	0.57735E+00	0.67383E+00	0.46210E+00	[illegible]	0.12400E+00	-0.55333E+00
2	0.32504E+00	0.67383E+00	0.57735E+00	0.30320E+00	0.46210E+00	[illegible]	0.26207E+00	-0.55116E+00
12	0.38303E+00	0.67383E+00	0.57735E+00	0.67383E+00	0.71067E+00	[illegible]	0.37339E-01	-0.11352E-01

EXTRA FLOW 0.57735 0.57735 0.57735

EXTRA FLOW 0.70711 0.00000 0.70711

SOLID ANGLE = - 12.549

XYZ POTENTIAL FLOW PROGRAM SECTION 2, VERSION 4

DATE: 22-APR-82 SUBROUTINE START TIME 14:11:00

SAMPLE PROBLEM SPHERE

```
XYZ POTENTIAL FLOW PROGRAM SECTION 3, VERSION 4

DAT : 22-APR-82          SUBROUTINE START TIME 14:11:17

      SAMPLE PROBLEM   SPHERE

X VELOCITY=-1.0    Y VELOCITY= 0.0    Z VELOCITY= 0.0

ITERATION   SUM OF CHANGES          A            B1            B2
    1        0.10255E+00
    2        0.19695E-01
    3        0.37817E-02
    4        0.72600E-03
    5        0.13938E-03

X VELOCITY= 0.0    Y VELOCITY=-1.0    Z VELOCITY= 0.0

ITERATION   SUM OF CHANGES          A            B1            B2
    1        0.10235E+00
    2        0.17635E-01
    3        0.37817E-02
    4        0.72597E-03
    5        0.13935E-03

X VELOCITY= 0.0    Y VELOCITY= 0.0    Z VELOCITY=-1.0

ITERATION   SUM OF CHANGES          A            B1            B2
    1        0.10255E+00
    2        0.17695E-01
    3        0.37817E-02
    4        0.72578E-03
    5        0.13935E-03
```

XYZ POTENTIAL FLOW PROGRAM SECTION 4, VERSION 4

DATE: 22-APR-82 SUBROUTINE START TIME 14:11:23
SAMPLE PROBLEM SPHERE

SAMPLE PROBLEM SPHERE PAGE = 1

X FLOW

PT.	X	Y	Z	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.93403	0.17163	0.17163	-0.09689	0.26213	0.26211	0.38313	0.35320	0.12393	0.26E-04	0.53241	1.46649
2	0.80023	0.52041	0.15346	-0.47232	0.56381	0.20542	0.84023	0.29407	0.10396	0.23E-04	0.45375	1.25399
3	0.80023	0.15846	0.52041	-0.47232	0.20541	0.66382	0.84023	0.29405	0.10396	0.23E-04	0.45376	1.25399
4	0.71067	0.46210	0.46210	-0.68729	0.52665	0.52666	1.01345	-0.02708	0.09321	0.20E-04	0.40444	1.11511
5	0.17163	0.93408	0.17163	-1.45656	0.26091	0.04533	1.48044	-1.19163	0.02424	0.46E-05	0.09935	0.26398
6	0.15346	0.80023	0.52041	-1.47125	0.20490	0.13186	1.49133	-1.22398	0.02153	0.49E-05	0.09054	0.24300
7	0.52041	0.80023	0.15944	-1.05796	0.66240	0.13032	1.25503	-0.57503	0.07160	0.15E-04	0.29542	0.91594
8	0.46210	0.71067	0.46210	-1.15476	0.53123	0.34067	1.31593	-0.73173	0.06417	0.13E-04	0.26429	0.72639
9	0.17163	0.17163	0.93409	-1.45653	0.04530	0.26091	1.48044	-1.19160	0.02425	0.46E-05	0.09934	0.26397
10	0.52041	0.15945	0.80023	-1.05798	0.13031	0.66242	1.25503	-0.57503	0.07160	0.15E-04	0.29543	0.91584
11	0.15946	0.52941	0.80023	-1.47125	0.13187	0.20490	1.49127	-1.22396	0.02159	0.47E-05	0.09051	0.24999
12	0.46210	0.46210	0.71067	-1.15475	0.34067	0.53122	1.31594	-0.73170	0.06417	0.13E-04	0.26429	0.72639

SAMPLE PROBLEM SPHERE PAGE = 2

Y FLOW

PT.	X	Y	Z	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.33408	0.17163	0.17163	0.26091	-1.45653	0.04530	1.4804[illegible]	-1.19160	0.02425	0.45E-05	0.09834	0.26777
2	0.80023	0.52041	0.15846	0.66242	-1.05798	0.13031	1.2550[illegible]	-0.57503	0.07160	0.15E-04	0.29543	0.81584
3	0.80023	0.15846	0.52041	0.20490	-1.47125	0.13187	1.4913[illegible]	-1.22396	0.02153	0.47E-05	0.09053	0.24999
4	0.71067	0.46210	0.46210	0.53122	-1.15475	0.34067	1.3159[illegible]	-0.73170	0.06417	0.13E-04	0.26429	0.72633
5	0.17163	0.93408	0.17163	0.26211	-0.09689	0.26213	0.3831[illegible]	0.85320	0.12393	0.25E-04	0.53241	1.46663
6	0.15846	0.80023	0.52041	0.20542	-0.47232	0.66381	0.8402[illegible]	0.29407	0.10396	0.23E-04	0.45375	1.25398
7	0.52041	0.80023	0.15846	0.66382	-0.47232	0.20541	0.8402[illegible]	0.29406	0.10396	0.23E-04	0.45376	1.25399
8	0.46210	0.71067	0.46210	0.52666	-0.68728	0.52665	1.0134[illegible]	-0.02708	0.09821	0.20E-04	0.40444	1.11511
9	0.17163	0.17163	0.93408	0.04533	-1.45656	0.26091	1.4804[illegible]	-1.19163	0.02424	0.46E-05	0.09935	0.26999
10	0.52041	0.15846	0.80023	0.13186	-1.47126	0.20490	1.4913[illegible]	-1.22398	0.02159	0.47E-05	0.09054	0.24900
11	0.15846	0.52041	0.80023	0.13032	-1.05796	0.66240	1.2550[illegible]	-0.57503	0.07160	0.15E-04	0.29542	0.81584
12	0.46210	0.46210	0.71067	0.34067	-1.15476	0.53123	1.3159[illegible]	-0.73173	0.06417	0.13E-04	0.26429	0.72639

SAMPLE PROBLEM SPHERE PAGE = 3

Z FLOW

PT.	X	Y	Z	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.33408	0.17163	0.17163	0.26091	0.04533	-1.45656	1.4804[illegible]	-1.19163	0.02424	0.46E-05	0.09935	0.26778
2	0.80023	0.52041	0.15846	0.20490	0.13186	-1.47126	1.4913[illegible]	-1.22398	0.02153	0.47E-05	0.09054	0.24900
3	0.80023	0.15846	0.52041	0.66240	0.13032	-1.05796	1.2550[illegible]	-0.57503	0.07160	0.15E-04	0.29542	0.81584
4	0.71067	0.46210	0.46210	0.53123	0.34067	-1.15476	1.3159[illegible]	-0.73173	0.06417	0.13E-04	0.26429	0.72639
5	0.17163	0.93408	0.17163	0.04530	0.26091	-1.45653	1.4804[illegible]	-1.19160	0.02425	0.46E-05	0.09934	0.26997
6	0.15846	0.80023	0.52041	0.13031	0.66242	-1.05798	1.2550[illegible]	-0.57503	0.07160	0.15E-04	0.29543	0.81586
7	0.52041	0.90023	0.15946	0.13187	0.20490	-1.47125	1.4913[illegible]	-1.22396	0.02153	0.47E-05	0.09053	0.24999
8	0.46210	0.71067	0.46210	0.34067	0.53122	-1.15475	1.3159[illegible]	-0.73170	0.06417	0.13E-04	0.26429	0.72638
9	0.17163	0.17163	0.93408	0.26213	0.26211	-0.09689	0.3831[illegible]	0.85320	0.12393	0.26E-04	0.53241	1.46663
10	0.52041	0.15846	0.90023	0.66381	0.20542	-0.47232	0.8402[illegible]	0.29407	0.10396	0.23E-04	0.45375	1.25399
11	0.15846	0.52041	0.90023	0.20541	0.66382	-0.47232	0.8402[illegible]	0.29406	0.10396	0.23E-04	0.45376	1.25399
12	0.46210	0.46210	0.71067	0.52665	0.52666	-0.68728	1.0134[illegible]	-0.02708	0.09921	0.20E-04	0.40444	1.11511

SAMPLE PROBLEM SPHERE PAGE = 4

ONSET FLOW, VXI= 0.577 VYI= 0.577 VZI= 0.577

PT.	X	Y	Z	VX	VY	VZ	ABS.V	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.93409	0.17163	0.17163	-0.24533	0.66342	0.66346	0.96979	0.05951	-0.42094	-1.15942
2	0.80023	0.52041	0.15946	-0.22805	0.15144	0.65560	0.71046	0.49524	-0.48481	-1.33977
3	0.80023	0.15945	0.52041	-0.22804	0.65560	0.15142	0.71045	0.49526	-0.48491	-1.33976
4	0.71067	0.46210	0.46210	-0.21661	0.16595	0.16595	0.91937	0.89800	-0.53867	-1.48256
5	0.17163	0.93408	0.17163	0.66346	-0.24533	0.66342	0.96979	0.05951	-0.42094	-1.15942
6	0.15846	0.80023	0.52041	0.65560	-0.22805	0.15144	0.71046	0.49524	-0.48481	-1.33977
7	0.52041	0.80023	0.15846	0.15142	-0.22804	0.65560	0.71045	0.49526	-0.48491	-1.33976
8	0.46210	0.71067	0.46210	0.16595	-0.21661	0.16595	0.91937	0.89800	-0.53867	-1.48256
9	0.17163	0.17163	0.93408	0.66342	0.66346	-0.24533	0.96979	0.05951	-0.42094	-1.15942
10	0.52041	0.15846	0.80023	0.15144	0.65560	-0.22805	0.71046	0.49524	-0.48481	-1.33977
11	0.15946	0.52041	0.80023	0.65560	0.15142	-0.22804	0.71045	0.49526	-0.48491	-1.33976
12	0.46210	0.46210	0.71067	0.16595	0.16595	-0.21661	0.91937	0.89800	-0.53867	-1.48256

SAMPLE PROBLEM SPHERE PAGE = 5

ONSET FLOW, VXI= 0.707 VYI= 0.000 VZI= 0.707

PT.	X	Y	Z	VX	VY	VZ	ABS.V	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.93409	0.17163	0.17163	-0.11599	-0.21740	0.84461	0.87982	0.22593	-0.44602	-1.22787
2	0.80023	0.52041	0.15946	0.18309	-0.56263	0.89509	1.07401	-0.15349	-0.33498	-1.06277
3	0.80023	0.15946	0.52041	-0.13441	-0.23740	0.27870	0.39000	0.84790	-0.52975	-1.46353
4	0.71067	0.46210	0.46210	0.11034	-0.61329	0.44414	0.76522	0.41445	-0.47286	-1.30213
5	0.17163	0.93408	0.17163	0.39791	-0.36899	0.99787	1.45848	-1.12772	-0.13908	-0.38180
6	0.15845	0.80023	0.52041	0.94920	-0.61329	0.65486	1.30540	-0.70404	-0.27292	-0.75296
7	0.52041	0.80023	0.15946	0.65485	-0.61329	0.94919	1.30537	-0.70399	-0.27231	-0.75295
8	0.46210	0.71067	0.46210	0.57565	-0.75127	0.57564	1.10777	-0.22714	-0.37375	-1.02724
9	0.17163	0.17163	0.93408	0.94457	-0.21737	-0.11598	0.87978	0.22600	-0.44601	-1.22785
10	0.52041	0.15846	0.80023	0.27872	-0.23739	-0.13442	0.39001	0.84789	-0.52975	-1.46359
11	0.15946	0.52041	0.80023	0.89509	-0.56264	0.18910	1.07401	-0.15349	-0.38487	-1.06277
12	0.46210	0.46210	0.71067	0.44414	-0.61329	0.11035	0.76522	0.41444	-0.47286	-1.30213

XYZ POTENTIAL FLOW PROGRAM SECTION 5, VERSION 4

DATE: 22-APR-82 SUBROUTINE START TIME 14:11:32

SAMPLE PROBLEM SPHERE

NOBP = 4
IEDITS= 0
IREAD = 0

OFF BODY POINTS

PT.	X	Y	Z
1	0.99900	0.88800	0.77700
2	15.00000	0.00000	-1.00000
3	-2.00000	3.00000	0.00000
4	0.00000	0.00000	2.00000

SAMPLE PROBLEM SPHERE OFF BODY POINTS PAGE 1

X FLOW

PT.	X	Y	Z	VX	VY	VZ	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.99900	0.88800	0.77700	-0.96442	0.15744	0.13783	0.02611	0.14131	1.14031
2	15.00000	0.00000	-1.00000	-0.99769	0.00000	-0.00003	0.00061	0.00231	15.00231
3	-2.00000	3.00000	0.00000	-1.00085	-0.01544	0.00000	-0.00194	-0.02231	-2.02231
4	0.00000	0.00000	2.00000	-1.06552	0.00000	0.00000	-0.13533	0.00000	0.00000

SAMPLE PROBLEM SPHERE OFF BODY POINTS PAGE 2

Y FLOW

PT.	X	Y	Z	VX	VY	VZ	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.99900	0.88800	0.77700	0.15754	-1.00148	0.12256	-0.04281	0.12563	1.01363
2	15.00000	0.00000	-1.00000	0.00000	-1.00015	0.00000	-0.00031	0.00030	0.00000
3	-2.00000	3.00000	0.00000	-0.01543	-0.98799	0.00000	0.02364	0.03345	3.03345
4	0.00000	0.00000	2.00000	0.00000	-1.06552	0.00000	-0.13533	0.00000	0.00000

SAMPLE PROBLEM SPHERE — OFF BODY POINTS — PAGE 3

Z FLOW

PT.	X	Y	Z	VX	VY	VZ	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.99900	0.08400	0.77700	0.13806	0.12271	-1.03431	-0.10392	0.19939	0.98599
2	15.00000	0.00000	-1.00000	-0.00003	0.00000	-1.00015	-0.00030	-0.00015	-1.00015
3	-2.00000	3.00000	0.00000	0.00000	0.00000	-1.01116	-0.02245	0.00000	0.00000
4	0.00000	0.00000	2.00000	0.00000	0.00000	-0.86914	0.24459	0.13074	2.13074

SAMPLE PROBLEM SPHERE — OFF BODY POINTS — PAGE 4

ONSET FLOW VX = 0.577
VY = 0.577
VZ = 0.577

PT.	X	Y	Z	VX	VY	VZ	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.99900	0.08400	0.77700	0.38415	0.41646	0.44682	0.47780	-0.21753	-1.75569
2	15.00000	0.00000	-1.00000	0.57719	0.57744	0.57746	-0.00006	-0.00124	-9.08414
3	-2.00000	3.00000	0.00000	0.58675	0.57933	0.58379	-0.02072	-0.00643	-0.58378
4	0.00000	0.00000	2.00000	0.61518	0.61518	0.50180	-0.00469	-0.07548	-1.23018

SAMPLE PROBLEM SPHERE — OFF BODY POINTS — PAGE 5

ONSET FLOW VX = 0.707
VY = 0.000
VZ = 0.707

PT.	X	Y	Z	VX	VY	VZ	CP	POTENTIAL (PERTURBATION)	POTENTIAL (TOTAL)
1	0.99900	0.48900	0.77700	0.58433	-0.19809	0.63391	0.21749	-0.17770	-1.63353
2	15.00000	0.00000	-1.00000	0.70692	0.00000	0.70724	0.00003	-0.00152	-9.90106
3	-2.00000	3.00000	0.00000	0.70771	0.01092	0.71500	-0.01213	0.01577	1.42993
4	0.00000	0.00000	2.00000	0.75344	0.00000	0.61458	0.05463	-0.07245	-1.50567

XYZ POTENTIAL FLOW PROGRAM SECTION 6, VERSION 4

DATE: 22-APR-82   SUBROUTINE START TIME 14:11:40

SAMPLE PROBLEM   SPHERE

3 STREAMLINES TO BE COMPUTED AT   4 STEPS OF   0.1500 T FOR AN ONSET VELOCITY OF   0.7071 0.0000 0.7071

STARTING POINTS

PT	X	Y	Z
1	0.00000	1.00000	1.00000
2	1.00000	1.00000	0.00000
3	1.00000	0.00000	1.00000

STEP 0

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.00000	1.00000	1.00000	0.83886	-0.19623	0.64175	-0.15403
2	1.00000	1.00000	0.00000	0.64175	-0.19623	0.83886	-0.15403
3	1.00000	0.00000	1.00000	0.44552	0.00000	0.44552	0.60303

STEP 1

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.12294	0.97062	1.09345	0.80052	-0.19273	0.60707	-0.04550
2	1.09345	0.97062	0.12294	0.60708	-0.19272	0.80052	-0.04651
3	1.07057	0.00000	1.07057	0.49416	0.00000	0.49415	0.51163

STEP 2

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.24033	0.94280	1.18231	0.76551	-0.17672	0.58832	0.03664
2	1.18232	0.94280	0.24033	0.58832	-0.17571	0.76552	0.03664
3	1.14781	0.00000	1.14780	0.53430	0.00000	0.53428	0.42307

STEP 3

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.35294	0.91791	1.27059	0.73725	-0.15449	0.58248	0.09332
2	1.27059	0.91791	0.35294	0.58248	-0.15448	0.73725	0.09332
3	1.23047	0.00000	1.23047	0.56678	0.00000	0.56678	0.35753

STEP 4

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.46188	0.89652	1.35810	0.71639	-0.13077	0.58548	0.12690
2	1.35810	0.89653	0.46188	0.58548	-0.13077	0.71633	0.12690
3	1.31750	0.00000	1.31749	0.59259	0.00000	0.59260	0.29767

3 STREAMLINES TO BE COMPUTED AT 4 STEPS OF -0.1500 T FOR AN ONSET VELOCITY OF 0.7071 0.0000 0.7071

STARTING POINTS

PT	X	Y	Z
1	0.00000	1.00000	1.00000
2	1.00000	1.00000	0.00000
3	1.00000	0.00000	1.00000

STEP 0

LINE	X	Y	Z	VX	VY	VZ	CP
1	0.00000	1.00000	1.00000	0.83886	-0.19623	0.64175	-0.15403
2	1.00000	1.00000	0.00000	0.64175	-0.19623	0.83886	-0.15403
3	1.00000	0.00000	1.00000	0.44552	0.00000	0.44552	0.60303

STEP 1

LINE	X	Y	Z	VX	VY	VZ	CP
1	-0.12854	1.02851	0.90011	0.87370	-0.18023	0.69259	-0.27551
2	0.90010	1.02851	-0.12854	0.69259	-0.18021	0.87370	-0.27549
3	0.93732	0.00000	0.93732	0.38897	0.00000	0.38896	0.69742

STEP 2

LINE	X	Y	Z	VX	VY	VZ	CP
1	-0.26146	1.05289	0.73171	0.89565	-0.14077	0.75367	-0.39001
2	0.73171	1.05288	-0.26146	0.75366	-0.14076	0.89565	-0.38998
3	0.88363	0.00000	0.88363	0.32617	0.00000	0.32616	0.78724

STEP 3

LINE	X	Y	Z	VX	VY	VZ	CP
1	-0.39616	1.06966	0.67400	0.89634	-0.07984	0.81502	-0.47404
2	0.67400	1.06965	-0.39616	0.81501	-0.07984	0.89634	-0.47401
3	0.83962	0.00000	0.83963	0.26042	0.00000	0.26041	0.86437

STEP 4

LINE	X	Y	Z	VX	VY	VZ	CP
1	-0.52907	1.07615	0.54774	0.87126	-0.00551	0.86560	-0.50339
2	0.54775	1.07615	-0.52906	0.86560	-0.00553	0.87127	-0.50339
3	0.80545	0.00000	0.80545	0.19604	0.00000	0.19603	0.92114

UXYZ POTENTIAL FLOW PROGRAM SECTION 7, VERSION 4

DATE: 22-APR-82   SUBROUTINE START TIME 14:12:11

SAMPLE PROBLEM   SPHERE

ON BODY STREAMLINES - INPUT DATA
VXI =   1.00000
VYI =   0.00000
VZI =   1.00000
NLIN=   2
JMAX=   0
IWRITE=   0
MACH NO=   0.00000

STREAMLINE STARTING POINTS

LINE	X	Y	Z	NSP
1	0.71000	0.45000	0.45000	4
2	0.17000	0.17000	0.95000	9

SAMPLE PROBLEM   SPHERE

ONSET FLOW, VXI= 1.000 VYI= 0.000 VZI= 1.000

LINE NO. 1 PASSING THROUGH QUADRILATERAL 4 WITH STARTING POINT, X= 0.71000 Y= 0.45000 Z= 0.45000

I	X	Y	Z	VX	VY	VZ	CP	K1	K2	H2	SL	V	P
1	0.47341	0.86003	-0.00015	0.35433	-0.92760	1.55360	-1.09263	0.52774	-0.12186	1.85495	0.00000	1.44459	7
2	0.66306	0.66982	0.31916	0.52450	-1.00099	1.00010	-0.15484	0.92376	-0.06203	1.30149	0.41390	1.07463	7
3	0.71309	0.45500	0.45500	0.14079	-0.85389	0.63013	0.42192	1.60175	0.05707	1.00000	0.47704	0.76032	4
4	0.73971	0.31054	0.56916	0.01140	-0.60425	0.36414	0.75100	2.65090	0.03965	0.67755	0.96327	0.49992	3
5	0.69345	0.08039	0.69305	0.00951	-0.18067	0.04025	0.90282	10.65003	-0.06214	0.18052	1.13059	0.13105	3

SAMPLE PROBLEM SPHERE

ONSET FLOW, VXI= 1.000 VYI= 0.000 VZI= 1.000

LINE NO. 2 PASSING THROUGH QUADRILATERAL 9 WITH STARTING POINT, X= 0.17000 Y= 0.17000 Z= 0.95000

I	X	Y	Z	VX	VY	VZ	CP	K1	K2	HZ	SL	V	P
1	0.00007	0.20153	0.75990	1.51892	-0.36672	-0.21672	-0.27486	1.01806	0.02995	1.21371	0.00000	1.12310	9
2	0.16735	0.16735	0.73565	1.20295	-0.30067	-0.16681	0.21734	1.30038	0.04027	1.00300	0.17295	0.88468	9
3	0.36203	0.11425	0.90343	0.75751	-0.22449	-0.26069	0.65391	2.13880	0.04213	0.71362	0.37534	0.58929	10
4	0.62095	0.00020	0.76610	0.13293	-0.02235	-0.12107	0.97381	4.72850	0.10690	0.19751	0.69352	0.16184	10

SECTION

I N [illegible]	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL CZ1	CZ4 CZ5 CZ6
1	0.30000E+00	0.52263E+00	[illegible]	0.96007E+00	0.17163E+00	[illegible]87E+00	0.12303E+00	-0.55519E+00
1	0.16306E+01	0.72598E+00	0.28901E+00	0.32788E+00	0.33409E+00	[illegible]743E+00	0.27060E+00	-0.55923E+00
	0.30000E+00	0.00000E+00	0.32[illegible]E+00	0.39263E+00	0.17163E+00	[illegible]487E+00	0.38023E-01	-0.11467E-01
1	[illegible]	0.32[illegible]E+00	0.70[illegible]E+00	0.30000E+00	0.15645E+00	[illegible]37E+00	0.12715E+00	-0.55114E+00
2	[illegible]	0.47[illegible]E+00	[illegible]738[illegible]E+00	0.70711E+00	0.30023E+00	[illegible]701E+00	0.26662E+00	-0.55936E+00
	[illegible]	0.72[illegible]E+00	0.573[illegible]E+00	0.70711E+00	0.52041E+00	[illegible]792E+00	0.35472E-01	0.53792E-02
2	[illegible]	0.70711E+00	0.67[illegible]E+00	0.32504E+00	0.52041E+00	[illegible]792E+00	0.12713E+00	-0.55845E+00
1	[illegible]	0.70711E+00	0.673[illegible]E+00	0.25503E+00	0.90023E+00	[illegible]701E+00	0.26661E+00	-0.55207E+00
7	[illegible]	0.10000E+00	0.70[illegible]E+00	0.52[illegible]E+00	0.15346E+00	[illegible]E+00	0.35472E-01	0.74343E-02

ND STI[illegible] POINT -PO[illegible] 0.7[illegible]

[illegible]	[illegible]	0.57[illegible]E+00	[illegible]	[illegible]	0.46219E+00	[illegible]54E+00	0.12409E+00	-0.55339E+00
[illegible]	0.38[illegible]E+00	[illegible]	[illegible]	[illegible]78[illegible]E+00	0.71957E+00	0.7[illegible]430E+00	0.26207E+00	-0.55115E+00
3	[illegible]	[illegible]	[illegible]	0.57383E+00	0.45217E+00	[illegible]954E+00	0.37339E-01	-0.11953E-01

ROTATIONAL D.O.F. SAMPLE

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XYZ POTENTIAL FLOW PROGRAM SECTION 1, VERSION 4

DATE: 24-MAY-82          SUBROUTINE START TIME 10:11:11

      SAMPLE PROBLEM   SPHERE

NO. OF QUADS.  =  12
NO. OF SECTIONS=   3
MAX. NO. OF ITERATIONS Q FLOW 150  R FLOW 150
3 PLANES OF SYMMETRY

CONVERGENCE CRITERIA , 0.00010

   ISP =  0

IEDIT1 =  0
IEDIT3 =  0
IEDIT4 =  0
ITAPE  =  0

XCENTER = 0.00
YCENTER = 0.00
ZCENTER = 0.00

CGX =    0.000
CGY =    0.000
CGZ =    0.000
```

SECTION 1

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL CZ1	CZ4 CZ5 CZ6
1	0.10000E+01	0.32383E+00	0.38308E+00	0.32384E+00	0.73409E+00	0.[illegible]748E+00	0.12302E+00	-0.55519E+00
1	0.00000E+00	0.00000E+00	0.32504E+00	0.38264E+00	0.17163E+00	0.[illegible]987E+00	0.27060E+00	-0.55928E+00
1	0.00000E+00	0.38268E+00	0.32504E+00	0.00000E+00	0.17163E+00	0.[illegible]987E+00	0.38023E-01	-0.11684E-01
1	0.32[illegible]E+00	0.38303E+00	0.57383E+00	0.70711E+00	0.30023E+00	0.[illegible]701E+00	0.12715E+00	-0.55114E+00
2	0.38268E+00	0.32504E+00	0.57383E+00	0.70711E+00	0.52041E+00	0.[illegible]792E+00	0.26563E+00	-0.55934E+00
2	0.30030E+00	0.32504E+00	0.30323E+00	0.00000E+00	0.15346E+00	0.[illegible]339E+00	0.35472E-01	0.53794E-02
2	0.32384E+00	0.70711E+00	0.57383E+00	0.38403E+00	0.30023E+00	0.[illegible]701E+00	0.12715E+00	-0.55945E+00
1	0.30000E+00	0.00000E+00	0.30323E+00	0.32504E+00	0.15345E+00	0.[illegible]339E+00	0.26663E+00	-0.55207E+00
3	0.15[illegible]E+00	0.70711E+00	0.573[illegible]E+00	0.32504E+00	0.52041E+00	0.[illegible]792E+00	0.35472E-01	0.74346E-02

QUESTIONABLE POINT -POOR FIT 0.7[illegible]E-03

2	0.33[illegible]E+00	0.57383E+00	0.57735E+00	0.57383E+00	0.71067E+00	0.[illegible]490E+00	0.12400E+00	-0.55333E+00
[illegible]	0.325[illegible]E+00	0.30[illegible]E+00	0.57735E+00	0.57[illegible]E+00	0.46210E+00	0.[illegible]954E+00	0.26207E+00	-0.55114E+00
4	0.32[illegible]E+00	0.67383E+00	0.57735E+00	0.30320E+00	0.46213E+00	0.[illegible]954E+00	0.37333E-01	-0.119[illegible]E-01

SECTION [illegible]

M N P	X1 Y1 Z1	X2 Y2 Z2	X3 Y3 Z3	X4 Y4 Z4	XP YP ZP	XN YN ZN	A FL CZ1	CZ4 CZ5 CZ6
1	0.[illegible]E+00	0.10000E+00	0.32504E+00	0.38263E+00	0.17163E+00	0.[illegible]887E+00	0.12902E+00	-0.55[illegible]E+00
1	0.[illegible]E+00	0.38[illegible]E+00	0.32504E+00	0.00000E+00	0.17163E+00	0.[illegible]937E+00	0.27060E+00	-0.55[illegible]E+00
[illegible]	0.10000E+01	0.[illegible]E+00	0.98[illegible]E+00	0.32383E+00	0.92403E+00	0.[illegible]748E+00	0.[illegible]E-01	-0.11494E-01
[illegible]	0.[illegible]E+00	0.32504E+00	0.573[illegible]E+00	0.70711E+00	0.52941E+00	0.[illegible]792E+00	0.12713E+00	-0.5511[illegible]E+00
2	0.30000E+00	0.32504E+00	0.[illegible]E+00	0.00000E+00	0.15946E+00	0.[illegible]339E+00	0.265[illegible]E+00	-0.55[illegible]E+00
10	0.[illegible]E+00	0.38303E+00	0.57[illegible]E+00	0.70711E+00	0.30024E+00	0.[illegible]701E+00	0.35472E-01	0.53793E-02
[illegible]	0.00000E+00	0.00000E+00	0.30329E+00	0.32504E+00	0.15345E+00	0.[illegible]339E+00	0.12715E+00	-0.5594[illegible]E+00
1	0.36268E+00	0.70711E+00	0.67[illegible]E+00	0.32504E+00	0.52041E+00	0.[illegible]792E+00	0.26663E+00	-0.55207E+00
11	0.[illegible]E+00	0.70711E+00	0.57383E+00	0.38804E+00	0.30023E+00	0.[illegible]701E+00	0.35472E-01	0.74347E-02

QUESTIONABLE POINT -POOR FIT 0.7[illegible]E-03

2	0.32[illegible]E+00	0.30320E+00	0.57735E+00	0.57383E+00	0.46213E+00	0.[illegible]954E+00	0.12400E+00	-0.55339E+00
[illegible]	0.32[illegible]E+00	0.57383E+00	0.57735E+00	0.30320E+00	0.46210E+00	0.[illegible]954E+00	0.26207E+00	-0.55115E+00
1[illegible]	0.33[illegible]E+00	0.67383E+00	0.57735E+00	0.57383E+00	0.71067E+00	0.[illegible]490E+00	0.37339E-01	-0.11352E-01

EXTRA FLOW 0.57735 0.57735 0.57735

EXTRA FLOW 0.70711 0.00000 0.70711

SOLID ANGLE = 12.54[illegible]

```
XYZ POTENTIAL FLOW PROGRAM SECTION 2, VERSION 4

DATE: 24-MAY-82          SUBROUTINE START TIME 10:11:37

      SAMPLE PROBLEM   SPHERE


XYZ POTENTIAL FLOW PROGRAM SECTION 3, VERSION 4

DATE: 24-MAY-82          SUBROUTINE START TIME 10:11:58

      SAMPLE PROBLEM   SPHERE
Q= 1.0RAD/SEC            R= 0.0RAD/SEC

ITERATION   SUM OF CHANGES        A          B1          B2
    1        0.21556E-03
Q= 0.0RAD/SEC            R= 1.0RAD/SEC

ITERATION   SUM OF CHANGES        A          B1          B2
    1        0.21554E-03
```

XYZ POTENTIAL FLOW PROGRAM SECTION 4, VERSION 4

DATE: 24-MAY-82 SUBROUTINE START TIME 10:12:09
SAMPLE PROBLEM SPHERE

SAMPLE PROBLEM SPHERE PAGE = 1

W FLOW PT.	X	Y	Z	VX	VY	VZ	ABS.V	SOURCE	V NORMAL (LEAKAGE)	POTENTIAL
	(ALL VALUES ARE BASED ON THE PERTURBATION DUE TO THE ROTATION OF THE BODY ALONE)									
1	0.33409	0.17163	0.17163	-0.00102	-0.00031	0.00014	0.00108	-0.00017	0.47E-05	-0.00017
2	0.30323	0.52041	0.15346	0.00023	0.00003	0.00023	0.00040	0.00015	-0.50E-05	0.00000
3	0.30323	0.15346	0.52041	0.00007	0.00009	-0.00027	0.00029	-0.00001	-0.39E-05	-0.00006
4	0.71367	0.46210	0.46210	-0.00072	-0.00065	-0.00072	0.00121	-0.00019	0.67E-05	-0.00017
5	0.17163	0.33409	0.17163	-0.00001	0.00000	0.00001	0.00002	0.00000	0.21E-08	0.00000
6	0.15346	0.30323	0.52041	-0.00006	-0.00016	-0.00013	0.00021	-0.00002	0.22E-05	-0.00002
7	0.52041	0.30323	0.15346	0.00014	0.00015	0.00004	0.00021	0.00003	-0.22E-05	0.00002
8	0.46210	0.71367	0.46210	0.00010	0.00000	-0.00010	0.00014	0.00000	-0.72E-09	0.00000
9	0.17163	0.17163	0.33409	-0.00014	0.00031	0.00102	0.00108	0.00017	-0.47E-05	0.00017
10	0.52041	0.15346	0.30323	0.00027	-0.00003	-0.00007	0.00029	0.00031	0.79E-05	0.00006
11	0.15346	0.52041	0.30323	-0.00024	-0.00003	-0.00023	0.00040	-0.00005	0.50E-05	0.00000
12	0.46210	0.46210	0.71367	0.00072	0.00065	0.00172	0.00121	0.00019	[illegible]	0.00017

SAMPLE PROBLEM SPHERE PAGE = [illegible]

W FLOW PT.	X	Y	Z	VX	VY	VZ	ABS.V	SOURCE	V NORMAL (LEAKAGE)	POTENTIAL
	(ALL VALUES ARE BASED ON THE PERTURBATION DUE TO THE ROTATION OF THE BODY ALONE)									
1	[illegible]	0.17163	0.17163	0.00101	-0.00014	0.00031	0.00106	0.00017	0.79E+00	0.00017
2	[illegible]	[illegible]	0.15346	-0.00007	0.00027	[illegible]	0.00029	0.00031	[illegible]	0.00006
3	[illegible]	[illegible]	[illegible]	[illegible]	-0.00023	-0.00003	0.00040	-0.00015	0.79E+00	0.00000
4	[illegible]	[illegible]	[illegible]	0.00072	0.00072	0.00065	0.00121	0.00019	[illegible]	0.00017
5	[illegible]	[illegible]	[illegible]	[illegible]	-0.00102	-0.00031	0.00105	-0.00017	[illegible]	-0.00017
6	[illegible]	[illegible]	[illegible]	0.00013	0.00024	[illegible]	0.00040	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	-0.00027	0.00007	0.00023	0.00029	-0.00031	[illegible]	-0.00006
8	[illegible]	[illegible]	[illegible]	[illegible]	-0.00072	[illegible]	0.00121	-0.00019	[illegible]	-0.00017
9	[illegible]	[illegible]	[illegible]	[illegible]	-0.00001	0.00000	0.00002	0.00000	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	-0.00004	[illegible]	0.00021	-0.00003	[illegible]	[illegible]
11	[illegible]	0.52041	[illegible]	0.00004	[illegible]	[illegible]	0.00021	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00014	0.00000	[illegible]	[illegible]

XYZ POTENTIAL FLOW PROGRAM SECTION 2, VERSION 4

DATE: 24 MAY 82   SUBROUTINE START TIME: 10:12:21

SAMPLE PROBLEM SPHERE

NBODP 4
IEDITS 0
IACAD 0

OFF BODY POINTS

PT.	X	Y	Z
1	0.53900	0.38300	0.77700
2	15.00000	0.00000	-1.00000
3	-2.00000	3.00000	0.00000
4	0.00000	0.00000	2.00000

SAMPLE PROBLEM SPHERE   OFF BODY POINTS   PAGE 1

Y FLOW   (ALL VALUES ARE BASED ON THE PERTURBATION DUE TO THE ROTATION OF THE BODY ALONE)

PT.	X	Y	Z	VX	VY	VZ	POTENTIAL
1	0.53900	0.38300	0.77700	0.00001	-0.00002	-0.00002	0.00000
2	15.00000	0.00000	-1.00000	0.00000	0.00000	0.00000	0.00000
3	-2.00000	3.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	2.00000	-0.00001	0.00000	0.00000	0.00000

SAMPLE PROBLEM SPHERE   OFF BODY POINTS   PAGE 2

Z FLOW   (ALL VALUES ARE BASED ON THE PERTURBATION DUE TO THE ROTATION OF THE BODY ALONE)

PT.	X	Y	Z	VX	VY	VZ	POTENTIAL
1	0.53900	0.38300	0.77700	-0.00002	0.00003	0.00001	0.00000
2	15.00000	0.00000	-1.00000	0.00000	0.00000	0.00000	0.00000
3	-2.00000	3.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	2.00000	0.00000	0.00000	0.00000	0.00000

THEORETICAL CONSIDERATIONS AND USER'S MANUAL FOR A MODIFIED XYZ POTENTIAL FLOW PROGRAM FOR CALCULATING FIVE DEGREES OF FREEDOM VELOCITY POTENTIALS
Paul J. Lefebvre
Launch and Handling Development Branch
Launcher Systems Department
TM No. 82-2076A
15 November 1982
IR/IED Project No. A43105
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